[redacted]SIFIED

473
Copy
RM L57D30a

NACA RM L57D30a

2p

N63 16240

Code-1

NACA

Classification Changed to
Declassified Effective 18 April 1963
Authority NASA CCN-3 By J.J.Carroll

RESEARCH MEMORANDUM

CALCULATION OF EXTERNAL-STORE LOADS AND CORRELATION WITH EXPERIMENT

By Percy J. Bobbitt, Harry W. Carlson,
and Albin O. Pearson

Langley Aeronautical Laboratory
Langley Field, Va.

OTS PRICE

XEROX $ 2.60 ph

MICROFILM $ 0.83 mf.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON

July 29, 1957

[redacted]

[redacted]

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

CALCULATION OF EXTERNAL-STORE LOADS AND CORRELATION WITH EXPERIMENT

By Percy J. Bobbitt, Harry W. Carlson,
and Albin O. Pearson

SUMMARY

16240

A theory for evaluating the mutual interference between a wing and tip tank has been extended to apply to store-pylon configurations. By use of this analysis and the flow-field formulas of NACA Research Memorandum L55L30b and NACA Technical Note 3938, theoretical store-pylon side-force estimates have been made for a number of store-pylon configurations. Comparisons of the theoretical estimates with experimental results recently obtained at the Langley Aeronautical Laboratory indicate that theory is capable of predicting satisfactorily a variety of effects. Considered in this paper are the separate effects of spanwise store position, chordwise store position, angle of sideslip, store fins, store-store interference, and fuselage indentation. The experimental data and theory indicate that the pylon and pylon-induced side forces are the largest contributors to the total store-pylon side force. A short bibliography of recent NACA publications dealing with store and missile loads is included.

INTRODUCTION

In reference 1, the results were presented of a study made to determine the ability of linearized theory to predict the side force acting on wing stores at supersonic speeds. Although the theoretical and experimental correlations of this study were made for only a limited number of configurations and one Mach number, indications were that linear theory might be capable of doing a satisfactory job. It was apparent also from this study that additional calculations and correlations were needed to refine the theoretical approach and at the same time further define its limitations or capabilities.

The purpose of the present paper is to present the results of some recent calculations and correlations made to partially fulfill this need and at the same time indicate the type of data now being obtained at the National Advisory Committee for Aeronautics which are pertinent to the store-loads problem. Of particular interest are the data presented herein on pylon loads and pylon-induced store loads.

A short bibliography of recent NACA publications dealing with store and missile loads is included.

[redacted]

SYMBOLS

M — Mach number, $\dfrac{\text{Free-stream velocity}}{\text{Velocity of sound in free stream}}$

α — angle of attack

b — wing span

d — maximum diameter of store

l_s — length of store

S_s — maximum store cross-sectional area

q — free-stream dynamic pressure

A_p — aspect ratio of pylon

b_p — span of pylon

S_p — pylon area

β — angle of sideslip, measured in radians or degrees as specified

$$\left(C_{Y_\beta}\right)_p = \frac{\text{Side force on pylon}}{qS_p\beta} \quad (\beta \text{ measured in radians})$$

$$\left(C_{Y_\beta}\right)_s = \frac{\text{Side force on store}}{qS_p\beta} \quad (\beta \text{ measured in radians})$$

$$C_{Y,s} = \frac{\text{Side force on store}}{qS_s}$$

$$C_{Y,sp} = \frac{\text{Side force on store and pylon}}{qS_s}$$

$$C_{n,s} = \frac{\text{Yawing moment on store}}{qS_s l_s},$$ positive moment tends to push store nose in toward fuselage for store attached to left half of wing

DISCUSSION

In order to gain some insight into the mutual interference effects between a store and pylon and thus into the division of loads, both a theoretical analysis and experimental program have been carried out. In this section, a short description of the theoretical analysis just referred to is presented followed by a discussion of the ability of this theory, when used in conjunction with the flow-field formulas of references 1 and 2, to predict a number of experimentally measured effects. Several points of interest discussed at the end of this section are illustrated by data obtained for stores situated below the wing but not connected with a pylon. Through the use of theory, an estimation of what the order of magnitude of these data might be if the store were connected with a pylon is made.

Theory for Store-Pylon Side Force

The complex, three-dimensional, nonplanar problem of determining rigorously the side load on a store and pylon attached to a finite wing is one of insurmountable difficulty. Obviously, some simplifying assumptions must be made and some rigor sacrificed if the problem is to be treated by analytical means. One of the most profitable simplifications which can be affected when evaluating the interference effects between the store, pylon, and wing is the replacement of the wing by an infinite reflection plane. Inherent in this simplification is that the magnitude of the lateral-flow velocity beneath the wing be determined separately and by other methods. (See refs. 1 and 2.)

The problem of determining the loads on a pylon-store reflection-plane configuration subjected to a uniform lateral flow can be analyzed in the same manner as a wing tip-tank configuration at an angle of attack since the insertion of an infinite plane, perpendicular to the wing and in the plane of symmetry, does not alter the flow pattern. When the configuration of wing, tip tank, and vertical reflection plane is rotated through 90°, the wing semispan becomes the pylon, the vertical reflection plane becomes the wing, and the tip tank becomes the store. Also, the uniform vertical velocity to which the wing and tip tank are subjected and which is equivalent to $V\alpha$ becomes the lateral-flow velocity and is given the value $-V\beta$. The wing tip-tank problem has been treated in reference 3; however, the ratios of tank diameter to wing semispan of the configurations for which numerical results were obtained were not high enough to be of use in evaluating pylon or store loads. Consequently the analytical procedure given in reference 3 has been utilized to extend the numerical results from values of d/b_p up to 0.3 to values of d/b_p up to 1.6.

Shown in figure 1 are the variations of the pylon and pylon-induced store forces in coefficient form with the ratio of the store diameter to pylon span. The nondimensionalizing area for these coefficients is the pylon area. Note that, when the store diameter is 1.6 times the pylon span, the pylon-induced side force on the store and the side force on the pylon are almost equal. It is conceivable that in this situation the pylon could contribute on the order of 20 to 25 percent to the total root bending moment.

Scope of Test Configurations

The curves given in figure 1 and the flow-field formulas of references 1 and 2 have been utilized to make side-force calculations for a number of configurations recently tested at the Langley Aeronautical Laboratory. Before making comparisons of the calculated and experimental results, it would seem appropriate to present a few details of the tests and test configurations.

Some idea of the scope of tests can be obtained from the two wing-body models and associated store and store-pylon configurations shown in figure 2. The wing-body and store-pylon configurations on the left of figure 2 were tested at a Mach number of 1.6 in the Langley 4- by 4-foot supersonic pressure tunnel; those on the right, at Mach numbers from 0.8 to 1.43 in the Langley 8-foot transonic pressure tunnel. In the 4-foot-tunnel tests, store and store-pylon loads have been obtained for a variety of store-pylon configurations and a number of spanwise and chordwise locations as indicated by the circles showing store midpoint locations. Five-component store forces and moments were measured in this investigation with the store in presence of the pylon, three components were measured for the store-pylon combination and the full six components for the wing body. The models were tested through an angle-of-attack range extending from -2° to 12° and an angle-of-sideslip range from -12° to 12°.

The wing-fuselage model and the two store shapes pictured on the right of figure 2 represent two separate investigations conducted in the Langley 8-foot transonic pressure tunnel. For the store without a pylon systematic investigations have been conducted using both the basic and contoured fuselages shown. The circles on the wing body at the right indicate the positions at which store forces and moments were obtained. In addition to being tested singly, several of the stores were tested in combination, that is, two stores on a panel. Forces and moments for the finned store were measured only on the contoured fuselage airplane configuration at two positions. These positions are indicated by the squares. In each of the investigations, five-component store forces and moments and three-component wing-fuselage forces and moments were obtained through an angle-of-attack range extending from -2° to 8°.

There is, evidently, a large amount of recent experimental data which can be utilized to test the worth of the theoretical methods. In subsequent figures showing experimental results and calculations for a variety of effects only a representative cross section of this data will be utilized.

Contribution of Store and Pylon to Combined Load

Given in figure 3 are the separate contributions of the store and pylon to the combined store-pylon side-force coefficient at a Mach number of 1.6. The angle of sideslip is zero as it is for all other figures unless otherwise noted. Data and curves shown are for a sweptforward pylon and store combination located at the 0.55-wing-semispan station. The vertical scale of figure 3, which is labeled side-force coefficient, is simply the particular side force being considered nondimensionalized by q and the maximum cross-sectional area of the store. Negative side-force coefficient indicates that the side force acting on the store or store-pylon located below the left-hand half-wing is directed toward the wing tip.

In the calculation of the total store-pylon load, the loads on the store and pylon are determined separately and added. The load acting on the store is itself further broken down into two separate components. One is the load on the store determined as if the pylon were not present and the other is the load induced on the store by the pylon. It should be noted that the latter of these two loads is determined by the use of figure 1. Fortunately for the stores used in the investigation in the Langley 4- by 4-foot supersonic pressure tunnel, experimental data is available for each of the store-load components in addition to the total store-pylon load. Consider first the side force acting on the store when no pylon is present. It is evident that for this condition the rate of change of the side force with angle of attack is underestimated by the theory. This is not surprising since a calculation of the lift-curve slope for the store alone in a uniform flow field underestimates experiment by about 50 percent. The use of static experimental force data for the isolated store to form a correction factor for the theoretical computations would lead to a more accurate estimate of this component if desired.

The total side force acting on the store when the pylon is added (see fig. 3), agrees rather well with the calculated curve. Evidently this agreement is fortuitous since the increment in the store side force caused by the insertion of the pylon is overpredicted; that is, the difference between the squares and circles is overpredicted. Perhaps the fact that the theoretical curves used to estimate this increment were meant primarily for an unswept pylon and also that the theoretical sidewash acted only over the rear portion of the pylon are partly responsible for the overprediction.

The total force acting on the store and pylon combination as determined by experiment and given by the diamonds agrees satisfactorily with theory which is the solid line. Contributing to this agreement is the overprediction of the slope and the underprediction of the zero angle of attack or thickness effects. It is interesting to note that the pylon, carrying about the same amount of side load as the store, contributes about 25 percent of the total root-bending moment.

Before leaving figure 3, it is of interest to translate the combined store-pylon side-force coefficient into terms of a load in pounds for a practical situation. For example, if an airplane of this configuration having a 40-foot wing span and operating at 40,000 feet and a Mach number of 1.6 were to experience the largest store-pylon force indicated, it would amount to 6,600 pounds.

Effect of Store Spanwise Location on the Store-Pylon Side-Force Coefficient

There are other limitations and inadequacies of the theoretical methods used which have not yet been mentioned that will be pointed out at the appropriate places subsequently. An excellent opportunity to illustrate one of these shortcomings is afforded by figure 4.

Figure 4 shows the effect of store spanwise location on the angle-of-attack variation of the store-pylon side-force coefficient. The relative position of the store-pylon configuration with respect to the wing leading edge remains the same for all three spanwise locations as indicated by the sketches. Looking first at the experimental points, it can be seen that as you go from the inboard to the outboard position there is an increase in the slope. Theoretical predictions using the supersonic leading-edge sidewash calculated for the free-stream Mach number of 1.6 (the solid-line curves) also show an increase in slope as the store moves outboard, but the rate at which the slope increases is overpredicted.

Schlieren photographs taken of these models, one of which is shown in figure 5, revealed that the wing leading edge, instead of being slightly supersonic as predicted by the theory, was actually subsonic. In order to demonstrate that better agreement between theory and experiment may be obtained if the physical flow field is more accurately represented, the wing angle-of-attack flow field was recalculated for the Mach number giving the same location of the Mach cone emanating from the wing root as indicated in the schlieren photograph. Use of this flow field in determining the store-pylon side forces resulted in the dashed-line curves. For the inboard location, calculations using the subsonic edge flow field did not yield a noticeable change; whereas, for the midspan and tip locations, better agreement resulted. The agreement in magnitudes might be further improved if the side forces induced by the wing-thickness flow field were also reevaluated. Because of the time required, only a very rough estimation of the wing thickness effect was made. This is true of most of the curves shown in subsequent figures.

Effect of Pylon Sweep and Store Chordwise Location

Having examined the effect of spanwise location on a particular store-pylon configuration, the next logical effect to discuss is that of store chordwise location and accompanying pylon sweep. The spanwise position for which data will be presented is at the 0.55-wing-semispan station. The store-pylon configurations at the different chordwise locations are shown by the sketches in figure 6. Actually since the pylon carries or induces the major portion of the total load, this figure might be more properly titled the effect of pylon sweep and location. The experimental data and theoretical curve for the most forward position are repeated from the previous figures. When the store is moved to the rear from the most forward position and the pylon becomes unswept, there is an increase in the slope and a slight decrease in the thickness effects. In this position, the pylon is almost completely immersed in the wing flow field and feels the maximum effect of the high flow angularities in the region just to the rear of the wing leading edge. The agreement between theory and experiment for this position is good. For the store in the rear position, a considerable change in the side-force coefficient angle-of-attack variation from those of the more forward positions is noted. This can be attributed to the fact that the sweptback pylon is situated in a region of much lower wing angle-of-attack sidewash and also that it is subjected to the inflow in the region of the trailing edge due to wing thickness. The theoretical slope, though somewhat less than it was for the other two locations, still overpredicts the experimental slope. The change in thickness effects, estimated, as mentioned before, in a rather rough manner, were also overpredicted. Generally speaking, the agreement for the three positions is satisfactory.

Effect of Sideslip on the Store-Pylon Side-Force Coefficient

Another factor which has a major influence on the magnitude of the side force a store-pylon will be required to carry is the angle of sideslip. Plotted in figure 7 is the variation of the store-pylon side-force coefficient with angle of sideslip for the sweptforward pylon and store combination located at the 0.55-semispan station. The angle of attack chosen to illustrate this effect is 8°. Note the large magnitude of the side-force coefficients at the highest angles of sideslip and also the steepness of the slope. A comparison of experimental curves indicates that more side force results from 1° of sideslip than from 1° of angle of attack but perhaps not as much more as might be expected. The theory used to obtain the solid-line curve assumes that the store and pylon are side slipped in the presence of an infinite flat plate hence the effect of the changing leading-edge sweep relative to the free-stream direction and the effect of the fuselage are neglected. It is evident that the simplified theory overpredicts the incremental load due to sideslip by about 50 percent. A more exact theoretical determination of the forces on a store attached to a sideslipped configuration may be obtained by determining the flow field beneath the sideslipped wing through the use of formulas contained in reference 4. It should be pointed out here that the rate of change of the side-force coefficient with angle of sideslip varied little from one position to another in this investigation.

[redacted]

Effect of Fins on Store Side-Force Coefficient

There are many stores in use today which employ fins. An indication of how important the fin loads are relative to the pylon and pylon-induced store loads may be obtained from figure 8. In this figure is plotted the variation of the store side-force coefficient with angle of attack. The vertical scale has been reduced by a factor of one-half from the previous figures so that the changes caused by the addition of the fins can be more easily seen. The store pylon and wing body on the left are the same as that used for a number of the previous figures and, it may be remembered, was tested in the Langley 4- by 4-foot supersonic pressure tunnel at a Mach number of 1.6. The configuration on the right is completely different in all respects and was tested in the Langley 8-foot transonic pressure tunnel at a variety of Mach numbers in addition to the Mach number for which data is given in this figure. For the store on the left, the addition of fins causes an increase in the slope and only negligible displacement in the zero angle-of-attack value. Theory adequately predicts the slope change but overestimates the displacement. For the store on the right, the addition of the fins causes a displacement in the curves though little change in slope. Theory for the fins-off situation accurately predicts the magnitude and rate of change with angle of attack of the store side-force coefficient. For the fins-on situation only the increment at zero angle of attack is predicted. This estimate is indicated by the tick mark. Because the fin closest to the wing is affected by the wing vortex wake, no attempt has been made to calculate the angle-of-attack variation with the fins on. For the store on the left, the effect of the fins is small when compared to the total side-force acting on the store and pylon. For the store on the right where the store-pylon side forces are much smaller, the effect of the fins assumes a more important role.

Interference Effects Between Inboard and Outboard Stores

Another source of store side forces is the flow field created by another store, particularly when this other store is located on the same half-wing as in a four-store or four-nacelle configuration. To give some idea of the magnitude of these effects and to indicate whether the store flow fields can be accurately predicted, figure 9 has been prepared. Shown on the left of figure 9 is the effect of the outboard store on the side force acting on the inboard store and on the right, the effect of the inboard store on the outboard-store side force. These stores were not connected to the wing with a pylon. The dashed lines and the circles are the theory and experiment for the side force on the store alone and the solid line and the squares for the side force on the store in the presence of the other store.

The points to be made relative to the inboard-store curves on the left are the large effect of the outboard store on the inboard and the accuracy with which this effect is predicted. The displacement of the two curves is primarily due to the radial flow away from the outboard store caused by the outboard-store thickness and is, therefore, almost independent of angle of attack. If the inboard store were connected to the wing by a pylon, the increment in store side-force coefficient instead of being of the order of 0.08 might be as large as 0.6 or 0.7 depending on the geometric characteristics of the pylon. An effect of this magnitude would most certainly have to be accounted for to obtain reliable values of the store-pylon side force. The calculated curves shown are based on linear theory corrected by use of experimental force data for the isolated area.

An examination of the right-hand plot shows that the change in the slope of the side-force-coefficient curve for the outboard store when the inboard store is added is fairly well predicted by theory. The magnitude agreement between theory and experiment for the outboard-store side-force coefficients is evidently not so good as for the inboard store. The reason for this is thought to be a local Mach number loss similar to that illustrated by the schlieren photograph of figure 5. In terms of store-store interference, this means that one store will affect the other furtner forward than it would if the local Mach numbers were the same as the free-stream Mach numbers. Experimental data are available which indicate the effect on the store-store interference of these Mach numbers losses. Some of these data are presented in figure 10.

Shown in this figure are the side forces and yawing moments on an inboard store, alone and in the presence of the outboard store, for Mach numbers of 1.43, 1.2, and 0.8. The stores for the test results pictured were located at the 0.28- and 0.70-wing-semispan stations. The dashed lines are for the inboard store alone and the solid lines are for the inboard in the presence of the outboard store. At a Mach number of 1.43, note that the outboard store has a negligible effect on the inboard store, whereas at a Mach number of 1.2 there is a large effect. If the local Mach number were supersonic, it would be impossible for the outboard store to effect the inboard store at a Mach number of 1.2. The fact that the induced moment on the inboard store at zero angle of attack is positive, or nose in, and the fact that the angle-of-attack variations at this Mach number are almost identical to those at subsonic speeds, typified by the $M = 0.8$ curves, indicates that the local flow is actually subsonic.

Effect of Fuselage Contouring

It is well known that contoured fuselages are in use on many of todays production and design stage airplanes. While effecting a change in the pressure field to yield a lower drag than the basic fuselage configuration, these indented fuselages also have an appreciable effect on the lateral flow field and hence on the loads induced on stores attached to the wing. An indication of the difference between the loads on a store located beneath wing-fuselage models with and without a fuselage indentation can be obtained from figure 11. The Mach number of experimental results plotted in this figure is 1.2. Data for two spanwise store positions, 0.28- and 0.5-wing-semispan stations, is depicted. Judging from the difference between the curves for the basic and indented fuselages the effect of fuselage indentation is to cause an increase in the outward flow in the vicinity of the leading edge, giving rise to a negative increment in the side force and negative and positive increments to the yawing moments for the inboard and outboard stores, respectively. If the stores were connected to the wing with a pylon the largest increment shown instead of being approximately 0.05 would be of the order of 0.3 or 0.4.

The effect of fuselage indentation on the surface pressures and flow fields of configurations at an angle of attack has not yet been analyzed theoretically. At zero angle of attack the area-rule papers of Lomax and Heaslet (ref. 5) and Nielsen and Pitts (ref. 6) permit an evaluation of these effects though the procedure is rather involved.

CONCLUDING REMARKS

It can be said that theoretical methods are capable of predicting satisfactorily a variety of effects. More detail in the calculations of some of these effects than used in the present paper seems desirable. The experimental data and theory indicate that the pylon and pylon-induced side forces are the largest contributors to the total store-pylon side force. The separate effects of spanwise store position, chordwise store position, angle of sideslip, store fins, store-store interference, and fuselage indentation all play a part in determining the store-pylon side loads.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., March 5, 1957.

REFERENCES

1. Bobbitt, Percy J., Malvestuto, Frank S., Jr., and Margolis, Kenneth: Theoretical Prediction of the Side Force on Stores Attached to Configurations Traveling at Supersonic Speeds. NACA RM L55L30b, 1956.

2. Bobbitt, Percy J., and Maxie, Peter J., Jr.: Sidewash in the Vicinity of Lifting Swept Wings at Supersonic Speeds. NACA TN 3938, 1957.

3. Hartley, D. E.: Theoretical Load Distributions on Wings With Cylindrical Bodies at the Tips. C.P. No. 147, British A.R.C., 1954.

4. Goldstein, S., and Ward, G. N.: The Linearised Theory of Conical Fields in Supersonic Flow, With Application to Plane Aerofoils. Aero. Quarterly, vol. II, pt. I, May 1950, pp. 39-84.

5. Lomax, Harvard, and Heaslet, Max. A.: A Special Method for Finding Body Distortions That Reduce the Wave Drag of Wing and Body Combinations at Supersonic Speeds. NACA RM A55B16, 1955.

6. Nielsen, Jack N., and Pitts, William C.: General Theory of Wave-Drag Reduction for Combinations Employing Quasi-Cylindrical Bodies With an Application to Swept-Wing and Body Combinations. NACA TN 3722, 1956. (Supersedes NACA RM A55B07.)

BIBLIOGRAPHY

Silvers, H. Norman, and King, Thomas J., Jr.: Investigation at High Subsonic Speeds of Bodies Mounted From the Wing of an Unswept-Wing—Fuselage Model, Including Measurements of Body Loads. NACA RM L52J08, 1952.

Robinson, Samuel W., Jr., and Zlotnick, Martin: A Method for Calculating the Aerodynamic Loading on Wing—Tip-Tank Combinations in Subsonic Flow. NACA RM L53B18, 1953.

Silvers, H. Norman, and O'Bryan, Thomas C.: Some Notes on the Aerodynamic Loads Associated With External-Store Installations. NACA RM L53E06a, 1953.

O'Bryan, Thomas C.: Flight Measurements of Aerodynamic Loads and Moments on an External Store Mounted Under the Wing of a Swept-Wing Fighter-Type Airplane. NACA RM L53G22, 1953.

Alford, William J., Jr., and Silvers, H. Norman: Investigation at High Subsonic Speeds of Finned and Unfinned Bodies Mounted at Various Locations From the Wings of Unswept- and Swept-Wing—Fuselage Models, Including Measurements of Body Loads. NACA RM L54B18, 1954.

Alford, William J., Jr., Silvers, H. Norman, and King, Thomas J., Jr.: Preliminary Low-Speed Wing-Tunnel Investigation of Some Aspects of the Aerodynamic Problems Associated With Missiles Carried Externally in Positions Near Airplane Wings. NACA RM L54J20, 1954.

Alford, William J., Jr., Silvers, H. Norman, and King, Thomas J., Jr.: Experimental Aerodynamic Forces and Moments at Low Speed of a Missile Model During Simulated Launching From the Midsemispan Location of a 45° Sweptback Wing-Fuselage Combination. NACA RM L54K11a, 1955.

Alford, William J., Jr.: Experimental Static Aerodynamic Forces and Moments at Low Speed on a Canard Missile During Simulated Launching From the Midsemispan and Wing-Tip Locations of a 45° Sweptback Wing-Fuselage Combination. NACA RM L55A12, 1955.

Alford, William J., Jr., Silvers, H. Norman, and King, Thomas J., Jr.: Experimental Static Aerodynamic Forces and Moments at Low Speed on a Missile Model During Simulated Launching From the 25-Percent-Semispan and Wing-Tip Locations of a 45° Sweptback Wing-Fuselage Combination. NACA RM L55D20, 1955.

Smith, Norman F., and Carlson, Harry W.: Some Effects of Configuration Variables on Store Loads at Supersonic Speeds. NACA RM L55E05, 1955.

Alford, William J., Jr.: Effects of Wing-Fuselage Flow Fields on Missile Loads at Subsonic Speeds. NACA RM L55E10a, 1955.

Guy, Lawrence D.: Loads on External Stores at Transonic and Supersonic Speeds. NACA RM L55E13b, 1955.

Smith, Norman F., and Carlson, Harry W.: The Origin and Distribution of Supersonic Store Interference From Measurement of Individual Forces on Several Wing-Fuselage-Store Configurations. II.- Swept-Wing Heavy-Bomber Configuration With Large Store (Nacelle). Lateral Forces and Pitching Moments; Mach Number, 1.61. NACA RM L55E26a, 1955.

Hamer, Harold A., and O'Bryan, Thomas C.: Flight Measurements of the Loads and Moments on an External Store Mounted Under the Wing of a Swept-Wing Fighter-Type Airplane During Yawing and Rolling Maneuvers. NACA RM L55G22, 1955.

Smith, Norman F., and Carlson, Harry W.: The Origin and Distribution of Supersonic Store Interference From Measurement of Individual Forces on Several Wing-Fuselage-Store Configurations. III.- Swept-Wing Fighter-Bomber Configuration With Large and Small Stores. Mach Number, 1.61. NACA RM L55H01, 1955.

Guy, Lawrence D., and Hadaway, William M.: Aerodynamic Loads on an External Store Adjacent to a 45° Sweptback Wing at Mach Numbers From 0.70 to 1.96, Including an Evaluation of Techniques Used. NACA RM L55H12, 1955.

Morris, Odell A.: The Origin and Distribution of Supersonic Store Interference From Measurement of Individual Forces on Several Wing-Fuselage-Store Configurations. IV.- Delta-wing Heavy-Bomber Configuration with Large Store. Mach Number, 1.61. NACA RM L55I27a, 1955.

Carlson, Harry W., and Geier, Douglas J.: The Origin and Distribution of Supersonic Store Interference From Measurement of Individual Forces on Several Wing-Fuselage-Store Configurations. V.- Swept-Wing Heavy-Bomber Configuration With Large Store (Nacelle). Mach Number, 2.01. NACA RM L55K15, 1956.

Hadaway, William M.: Aerodynamic Loads on an External Store Adjacent to an Unswept Wing at Mach Numbers Between 0.75 and 1.96. NACA RM L55L07, 1956.

Smith, Norman F.: The Origin and Distribution of Supersonic Store Interference From Measurement of Individual Forces on Several Wing-Fuselage-Store Configurations. VI.- Swept-Wing Heavy-Bomber Configuration With Stores of Different Sizes and Shapes. NACA RM L55L08, 1956.

Hallissy, Joseph M., Jr., and Kudlacik, Louis: A Transonic Wind-Tunnel Investigation of Store and Horizontal-Tail Loads and Some Effects of Fuselage-Afterbody Modifications on a Swept-Wing Fighter Airplane. NACA RM L56A26, 1956.

Hadaway, William M.: Aerodynamic Loads on an External Store Adjacent to a 60° Delta Wing at Mach Numbers From 0.75 to 1.96. NACA RM L56B02a, 1956.

Alford, William J., Jr., and King, Thomas J., Jr.: Experimental Static Aerodynamic Forces and Moments at High Subsonic Speeds on a Missile Model During Simulated Launching From the Midsemispan Location of a 45° Sweptback Wing-Fuselage-Pylon Combination. NACA RM L56J05, 1957.

Alford, William J., Jr., and King, Thomas J., Jr.: Experimental Static Aerodynamic Forces and Moments at High Subsonic Speeds on a Canard Missile During Simulated Launching From the Midsemispan Location of a 45° Sweptback Wing-Fuselage-Pylon Combination at Zero Sideslip. NACA RM L56J15a, 1957.

Alford, William J., Jr., and King, Thomas J., Jr.: Experimental Investigation of Flow Fields at Zero Sideslip Near Swept- and Unswept-Wing—Fuselage Combinations at Low Speed. NACA RM L56J19, 1957.

Alford, William J., Jr.: Theoretical and Experimental Investigation of the Subsonic-Flow Fields Beneath Swept and Unswept Wings With Tables of Vortex-Induced Velocities. NACA TN 3738, 1956.

VARIATION OF STORE AND PYLON FORCES
WITH RATIO OF STORE DIAMETER TO PYLON SPAN

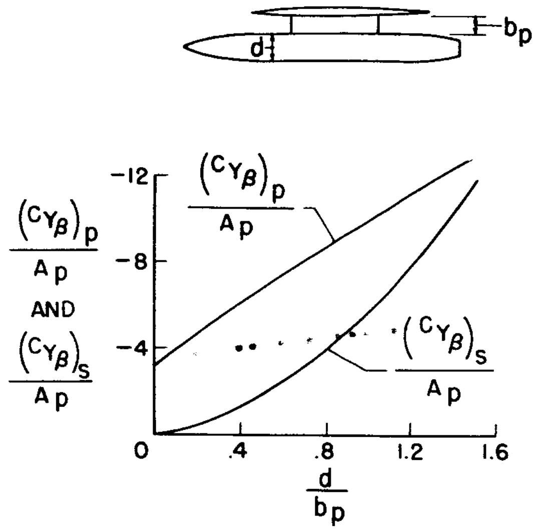

Figure 1

SCOPE OF TEST CONFIGURATIONS

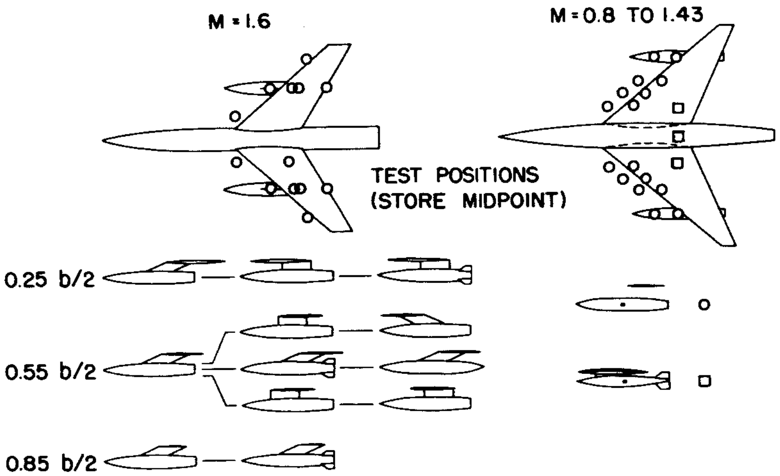

Figure 2

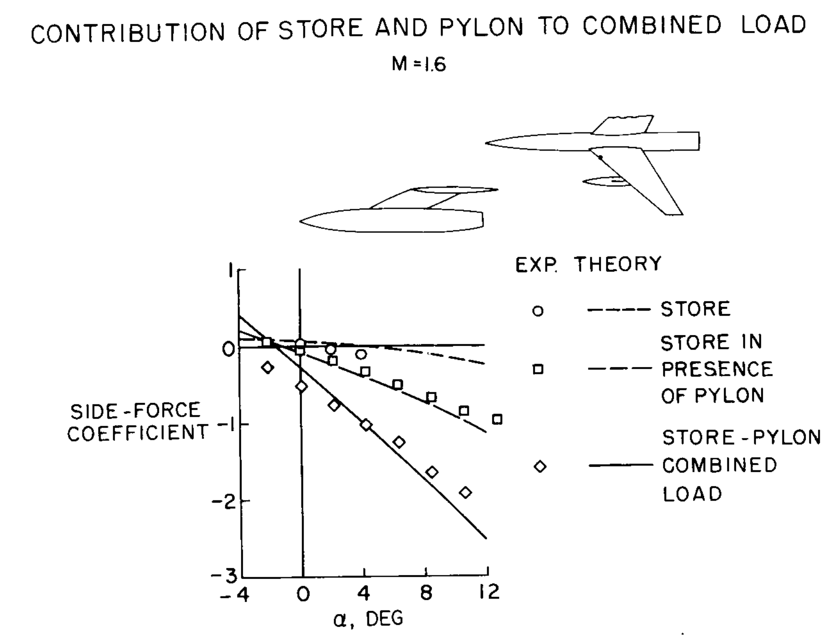

Figure 3

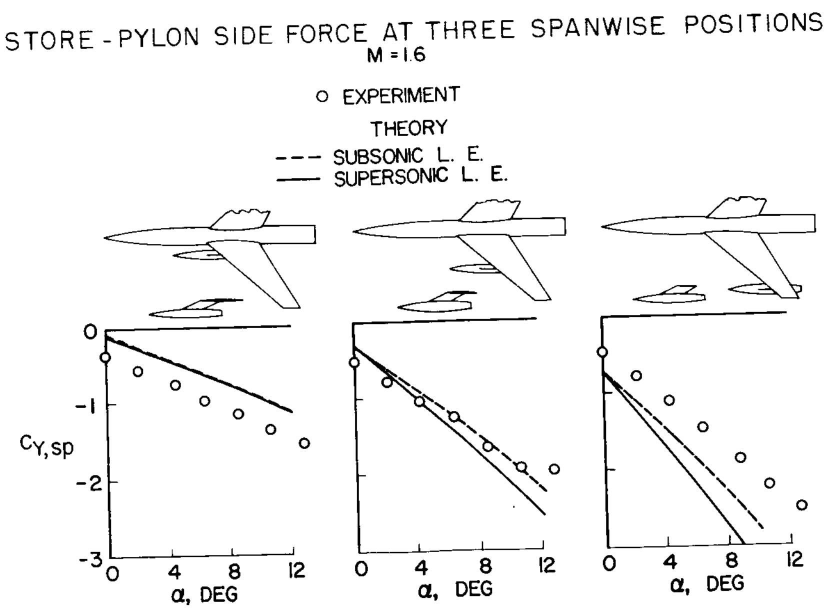

Figure 4

[redacted]

SCHLIEREN PHOTOGRAPH OF TEST CONFIGURATION
M = 1.6 ; α = 0°

Figure 5 L-57-179

EFFECT OF PYLON SWEEP AND STORE CHORDWISE LOCATION
M = 1.6

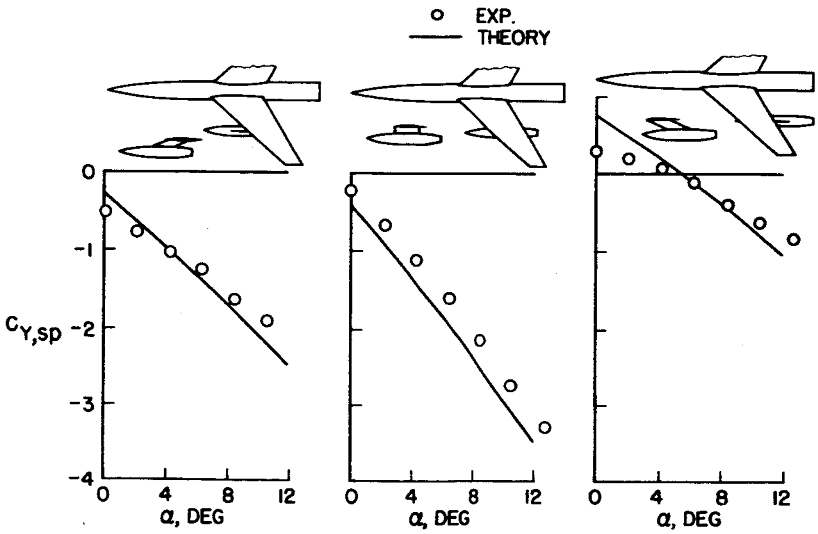

Figure 6

[redacted]

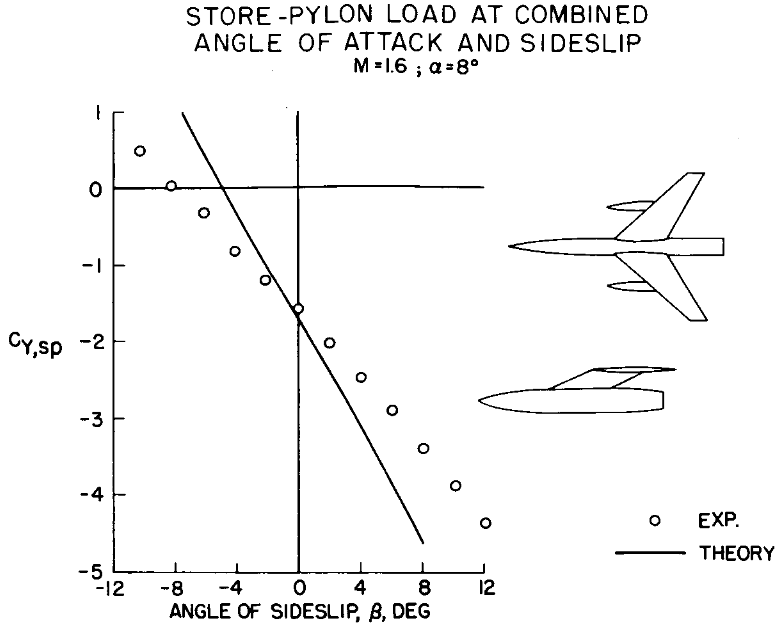

Figure 7

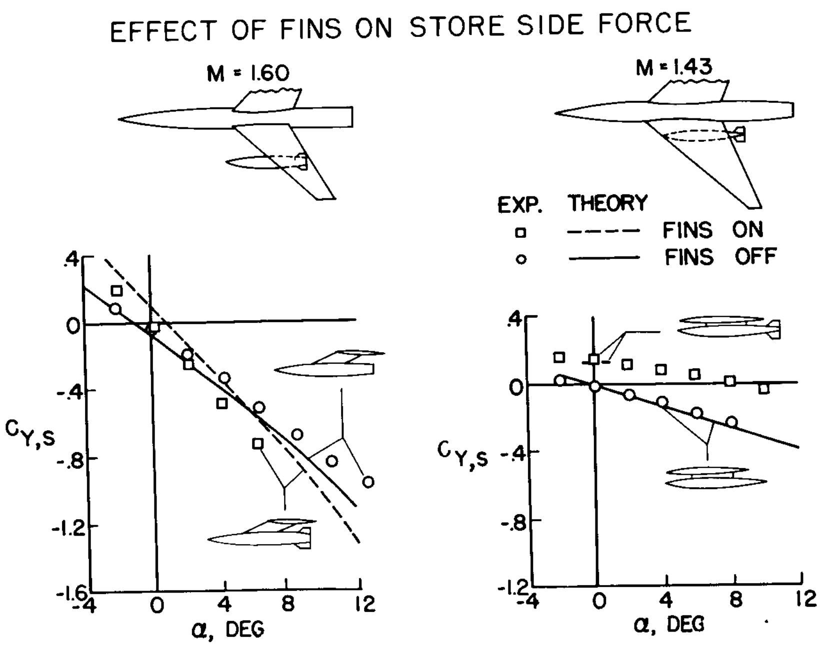

Figure 8

[redacted]

[redacted]

INTERFERENCE EFFECTS BETWEEN INBOARD AND OUTBOARD STORES

M = 1.43

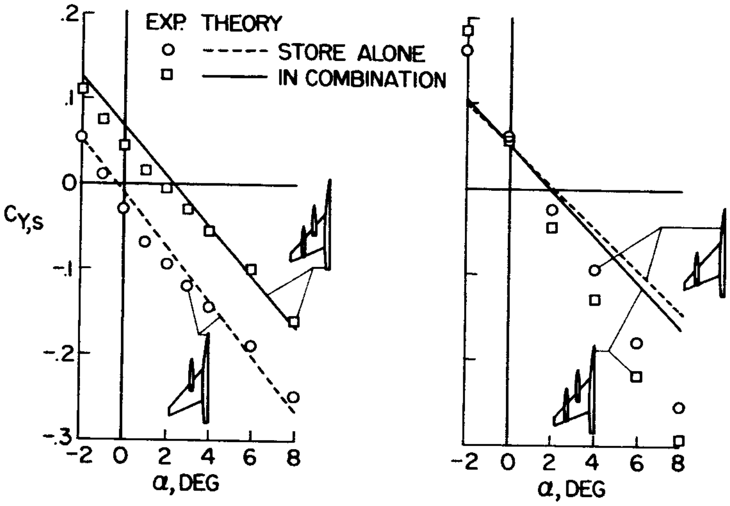

Figure 9

EFFECT OF MACH NUMBER ON STORE SIDE FORCE AND YAWING MOMENT

EXPERIMENTAL DATA

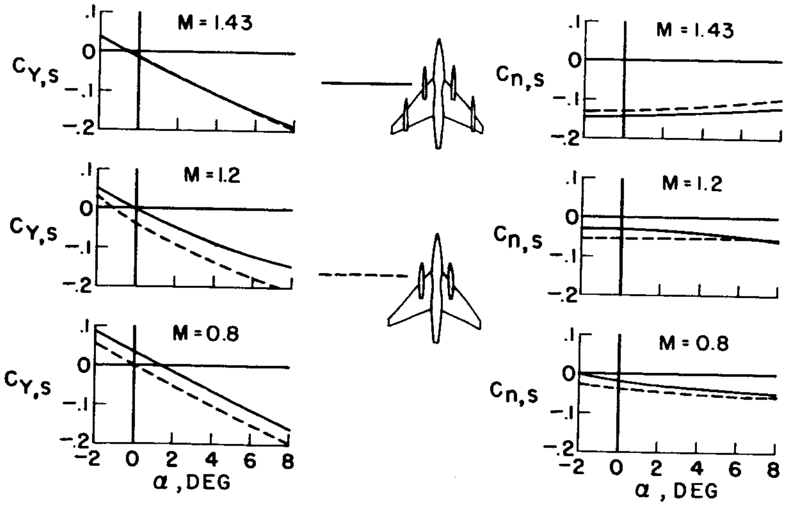

Figure 10

[redacted]

EFFECT OF FUSELAGE INDENTATION ON STORE SIDE FORCE AND YAWING MOMENT

M = 1.2

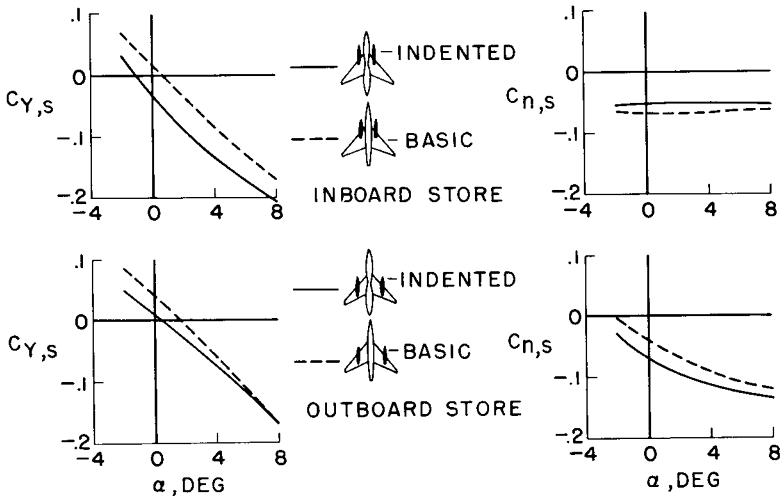

Figure 11

[redacted]